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Did farmers' livelihood improve? An impact assessment of incorporating forages into the crop-livestock system in the coastal savannah zone of Ghana

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Abstract

The study used programming methods to assess the farm-level impact of incorporating forages, including dual purpose *Cajanus cajan* (*C. cajan*)*,* into the crop-livestock system in the Coastal Savannah Zone of Ghana. The system was modeled in GAMS and solved using linear programming. The optimal enterprise mixes and their resultant net revenues with and without the interventions and therefore the change in net revenue were obtained. The intervention was to grow forages as part of the crop-livestock system and feed them to milking cows and their calves for increased milk production and growth. The grain of the forage was used as food by the farmers, and manure from the animals was also used for crop production. The effect of policy options like educating farmers to accept and use *C. cajan* grain as food and thereby increase its production was analysed. The change in net revenue with incorporation of *C. cajan* into the system was 50 percent. A 5 percentage points change in the inclusion level of *C. cajan* grain in farmers' diet and subsequent increase in its cultivation precipitated a 4 percent change in net revenue. *C. cajan* was not produced beyond the level required for household consumption and its main attraction seemed to be its food value. The addition of *C. cajan* into the crop-livestock system of the area improved farmers' incomes. Increased cultivation of C. c*ajan* may be dependent on the food value of the crop for the household.

Keywords: GAMS, Ghana, Grain, Forages

Introduction

The people of the Coastal Savannah zone of Ghana are mostly farmers who practise mixed farming. They keep livestock including cattle, which serves as a store of wealth (Kaya et al., 2000, Ouma et al., 2003); however, they may obtain regular incomes from and crop, and milk production. Milk income usually dwindles or is nil in the dry season when grass dries up. Forages have been introduced into crop-livestock systems and used as feed for animals (Atwal and Asare 1980, Inaizumi et al., 1999). Such feed supplementation increases weight gain (Oddoye et al., 2002), milk, and manure yields of cows and consequently crop yield, when manure is applied to them. Between 2003 and 2005 the CSIR-Animal Research Institute, Ghana, and some partners introduced forages into some communities of the Coastal Savannah of Ghana. This provided herbage for animal feed supplementation, and grains which may also be consumed by farmers to improve household food security and nutrition. The primary objective of this study was therefore to assess the farm level impact of the technologies introduced. The specific objectives were 1. to estimate the change in net returns for a representative farm with and without the interventions and 2. to analyse the effect of promoting cajanus seed consumption by farmers on net returns. The impact envisaged is at farm-level, as the new technologies were limited to only two communities and involved 24 farmers. Therefore, the Benefit Cost Analysis (BCA) or linear programming could be used for the current study. In addition to being based on activity budgets, like the BCA, linear programming factors in farmers' behaviour or response to new technologies (Rich et al., 2005). Hence the linear programming was used for the analysis.

Materials and Methods

The base scenario

*The objective function***.** Farmers maximize net returns cash income (Z), that is income from cash commodities less labour and non-labour costs of producing both cash and food commodities (equation 1).

$$Z = \sum_d \sum_j p_{dj} y_{dj} x_j - \sum_i \sum_j q_{ij} r_{ij} x_j - \sum_a \sum_j l_{aj} lp_{aj} x_j - \sum_i \sum_j qh_{ih} rh_{ih} xf_h - \sum_a \sum_h lh_{ah} lph_{ah} xf_h \qquad (1)$$

The indices j,h,d,a and i denote cash commodities, food commodities, products derived from the commodities, type of labour activity, and type of non-labour activity, respectively. For cash commodities, p is price, y is yield, x is area cultivated, q is quantity of non-labour input used, r is price of non-labour input, l is quantity of labour used per area, and lp is the price of labour used. For food commodities, xf is area cultivated, qh is quantity of non-labour input used, rh is unit cost of non-labour input, lh *is* quantity of labour used per area, lhp is price of labour used per area. In the base scenario, maize, cassava, pepper, tomatoes and okro were considered. These could both be cash or food commodites. Grains, crop residues, and milk could be obtained from each commodity. Labour was used for planting, weeding, harvesting, processing, preservation, feeding of cows and calves, and applying chemicals on crops.

The constraints

Net return was mazimised subject to capital, and labour availability, and food security requirements (see for instance, Abdoulaye and Deboer 2000). Food security is achieved when the total nutrient availability (N) for a year (365 days) is greater or equal to the household demand (Equation 2).

$$N_v = \sum_h n_{vh} gy_h xf_h \geq \sum_g c_{vg} s_g \; 365 \qquad (2)$$

where n is the amount of nutrient available in a kg of edible portion of commodity, gy is the yield of food commodities (kg), c is the consumption per person per day, and s is the household size. The indices vh, and vg, denote the amount of nutrient in food commodities, and nutrient requirement per person in age class g. Nutrients (v) considered comprised energy, protein, vitamin C, calcium, iron, vitamin A, and niacin. Total household food consumption (F) was defined as $F = \sum_h gy_h xf_h$, and a minimum level (m) of each food commodity is consumed as part of the diet (equation 3).

$$gy_h xf_h - m_h F \geq 0 \qquad (3)$$

Labour availability (for all commodities) could exceed or equal labour demand (equation 4).

$$\sum_a \sum_j l_{aj} x_j + \sum_a \sum_h lh_{ah} xf_h \leq \sum_g f_g s_g \; 80 \qquad (4)$$

where f denotes the labour equivalence for age categories of adult male, adult female and a child. Eighty (80) days of work was required per person per annum. It was assumed that the farmers had access to only equity capital. The baseline survey results showed that on the average farmers cultivated 5ha of land. Ploughing of land was a major activity for which cash was required and without that one could not cultivate much land. The amount required to cultivate the 5 ha (at 750,000 cedis per ha) was thus made the maximum they could get. Thus, capital requirement could not exceed this amount (equation 5).

$$\sum_j 750x_j + \sum_h 750xf_h \leq 3750 \qquad (5)$$

Non-negativity constraints were placed on the areas of cash and food commodities cultivated, as well as total consumption such that $x \geq 0$; $xf \geq 0$; $F \geq 0$.

Integration of cajanus with livestock

With the introduction of cajanus, the farmer had to reallocate his resources in order to accommodate the new enterprise. New activities, and enterprise herein called "Caj-milk", were introduced, for instance, cajanus leaves were harvested, preserved and fed to milking cows, which led to increased milk production in cows and greater calf weight gain. Cajanus grain was also harvested and used as food. Thus, in the scenario for integration of cajanus with livestock, these extra benefits and costs were added to the expression for net returns in equation 1. The benefit from cajanus residue feeding was obtained by valuing the portion of additional milk production attributed to the residue feeding.

Impact

The difference in the net returns with and without the new technology constituted the impact on farmers' incomes and livelihood. The scenarios with and without the intervention were modeled and solved using linear programming for the optimal allocation of resources to the various enterprises, and the consequent net returns. Increase in the production of the commodity was not large enough to depress its market price. Thus it was assumed that the same price levels prevailed in each scenario. The impact of the promotion of cajanus grain as food on the incomes of households (through increased cultivation for food and herbage and thus milk and calf weight gains) was assessed by assuming that the level of inclusion of cajanus grains in diets increased from 15 percent to 20 percent as a result of some policy action like education and training.

The data

Data on cajanus seed requirement, biomass and grain yields, levels of supplementation, and milk yield response to on-farm supplementation were obtained from on-farm trials. Amount of nutrients in commodities were obtained from the FAO Database on food composition tables for use in Africa. Nutrient requirements per person were also obtained from literature. Other input requirements including number of ploughings, planting materials, chemicals, labour requirements, and input prices were obtained from a combination of field survey and literature. Average household size and proportion of staple in food bundle were obtained from field survey.

Results and Discussion

The allocation of land to each food commodity was usually under 1ha (Table 1) in all the 3 scenarios modeled (without cajanus, with cajanus, and with cajanus utilization increased). Results of the baseline survey, however, showed that allocation of land to cassava and pepper were slightly more than 1 ha. The amount of land allocated to pepper produced for cash increased when the amount of land allocated to cajanus increased. In the scenarios modeled, pepper was the only commodity produced for cash and the area cultivated increased from 2.85 ha in the base scenario to 3.65 in the scenario with cajanus, and further to 3.75 when increase in cajanus utilization caused further cultivation. The opportunity cost for shifting a ha of land from pepper to other crops were the loss of the following amount in thousands of cedis: maize (5740), cassava (7940), cajanus-milk enterprise (3395), tomatoes (4340), and okro (5330). The net returns for the base scenario (without cajanus), the scenario with cajanus-livestock interation, and the scenario where utilization of cajanus increased were 23,290,783 cedis, 35,032,238 cedis, and 36,557,924 cedis respectively. Generally, the land allocation to commodities observed in the field (baseline survey), the modeled scenarios of without cajanus, with cajanus, and with cajanus utilization increased, were not too different, which suggests that the models are valid. Pepper was the only commodity produced for the market in the modeled situations, because it had the highest net returns. Shifting a ha of land from pepper to the production of maize, cassava, cajanus, tomatoes, and okro could reduce net returns by 574, 794, 340, 434, 533 thousand cedis respectively. The production of cajanus appeared to release more land for the cultivation cash commodities. Cajanus was not produced for the market and its main attraction seemed to be its food value. The introduction of cajanus into the livestock system, however, increased net returns by 50 percent. This agrees somewhat with Inaizumi et. al. (1999) who found that farmers obtained substantial cash income from the adoption of dual purpose cowpea and considered it more dependable than other crops. This is also consistent with Kaya et. al. (2000) who noted that the generation of multiple benefits from fodder crops, including more milk production through feeding fodder to cows, is required to make fodder cultivation attractive. Increasing the inclusion level of cajanus grains in the diet from 15 percent to 20 percent (5 percentage points) led to a 4 percent increase in net returns.

Conclusions

The integration of cajanus with livestock led to increase in net returns, thus impact was positive. Increased utilization of cajanus improved net returns.

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Table 1. Allocation of land to crops food commodities (in hectares)

	Maize	Pepper	Cassava	Caj-milk	tomatoes	Okro
Baseline (Ha)	0.83	1.13	1.45	-	0.44	0.10
Base scenario (Ha)	0.77	0.22	0.56	-	0.37	0.23
With Cajanjus (Ha)	0.31	0.12	0.26	0.32	0.21	0.13
More Cajanus Use	0.28	0.11	0.19	0.26	0.18	0.11